



Met Office

# What can RTTOV-9 do for me?

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Pascal Brunel and Philippe Marguinaud (MeteoFrance)

# Talk outline

- What is RTTOV? **R**adiative **T**ransfer for **TOVs**
- Differences from RTTOV-8
- Coefficient files
- Profile Interpolation
- Performance on various platforms
- How do I get it?
- Performance for IASI (Marco's talk)

# What is RTTOV?

View angle +  
sun angles



Estimate of atmospheric state  
and surface parameters for  
observation point  $X$



**RT model  
for required sensor**



Time ~ 1ms  
for 20 chans

Radiances for required satellite channels  $y=H(X)$   
and optionally jacobians  $H \equiv \frac{\partial y_i}{\partial X_j}$   
as TL, AD, or K

# RTTOV status

RTTOV-87 status released May 2005

**Number of licence requests = 313**

RTTOV-91 status released Mar 2008

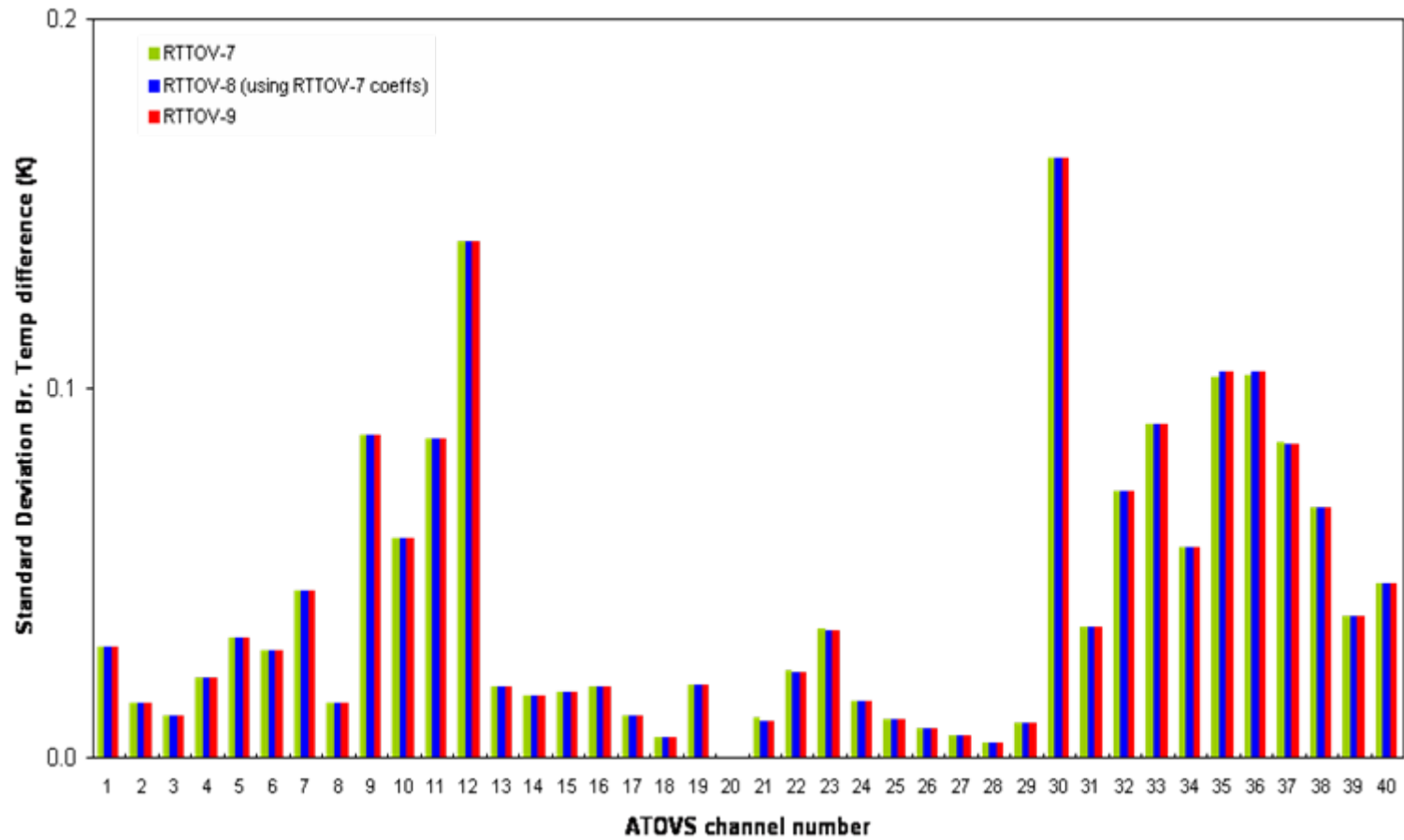
**Number of licence requests = 53**



# Differences from RTTOV-8

- Parameterised aerosol scattering for a range of user aerosol components
- New cloud parameterised scattering for infrared sensors inside RTTOV
- Linear in optical depth approximation for the Planck function to improve the accuracy of the radiance computation
- Include reflected solar radiation for wavelengths below 5 microns.
- Now six variable gas profiles which can be supplied to RTTOV ( $H_2O$ ,  $O_3$ ,  $CO_2$ , +  $N_2O$ ,  $CO$ ,  $CH_4$ )
- Further optimisation of optical depth computations for all gases for high resolution IR sensors (RTTOV-9 predictors)
- An altitude dependent variation of local zenith angle and optionally allow for atmospheric refraction
- The input profile levels can be defined by user and the radiances and transmittances output are on the same levels allowing better mapping of computed jacobians on to user levels
- Simplified interface to avoid need to specify polarisation (NB SSM/I chan numbers)
- The 2m surface humidity variable can now be an active variable in the state vector
- The Mie scattering tables used by RTTOV\_SCATT updated to increase their dynamic range

# Performance for ATOVS



# New coefficient files available

## MeghaTropiques

- Saphir and Madras (to be updated)

## DMSP-F14

- SSM/T-2

*Coming soon:*

*DMSP-F17 SSMIS*

*FY-3 sensors*

*NPP sensors*

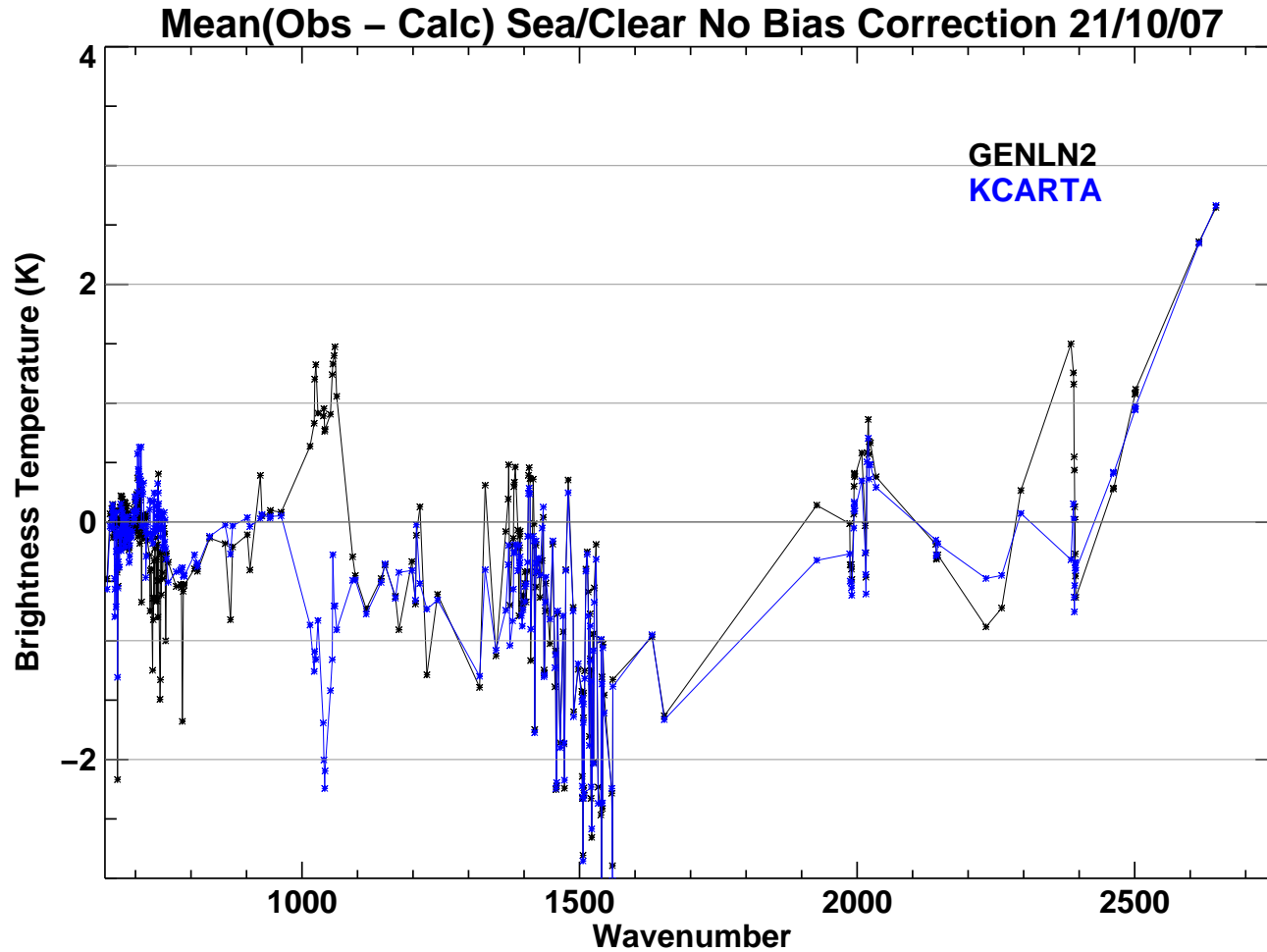
# RTTOV-9 coefficient files

## Infrared

- Radiometers
  - GENLN2 RTTOV-7 predictors
- IASI/AIRS options:
  - GENLN2 RTTOV-7
  - kCarta RTTOV-7 (METO ops, ECMWF ops)
  - GENLN2 RTTOV-9 (all trace gases)
  - LBLRTM coming soon with new 90L profile set



# Comparison of GENLN2 vs kCarta



# RTTOV coefficient file options

Gas	RTTOV-7 Code RTTOV-7 predictors only		RTTOV-8 code RTTOV-7/8 predictors (NB only 7 for MW)		RTTOV-9 code RTTOV-7/8/9 predictors (7 for MW, 9 for Hires)	
	Profile	Coeffs	Profile	Coeffs	Profile	Coeffs
Mixed	Y	Y	Y	Y	Y	Y
H2O	Y	Y	Y	Y	Y	Y
O3	Y	O	O	O	O	O
CO2	N	N	O	O	O	O
N2O	N	N	N	N	O	O
CO	N	N	N	N	O	O
CH4	N	N	N	N	O	O

Y=Mandatory  
O=Optional  
N=Not possible

**All 43 levels except AIRS/IASI which can be 101 levels**

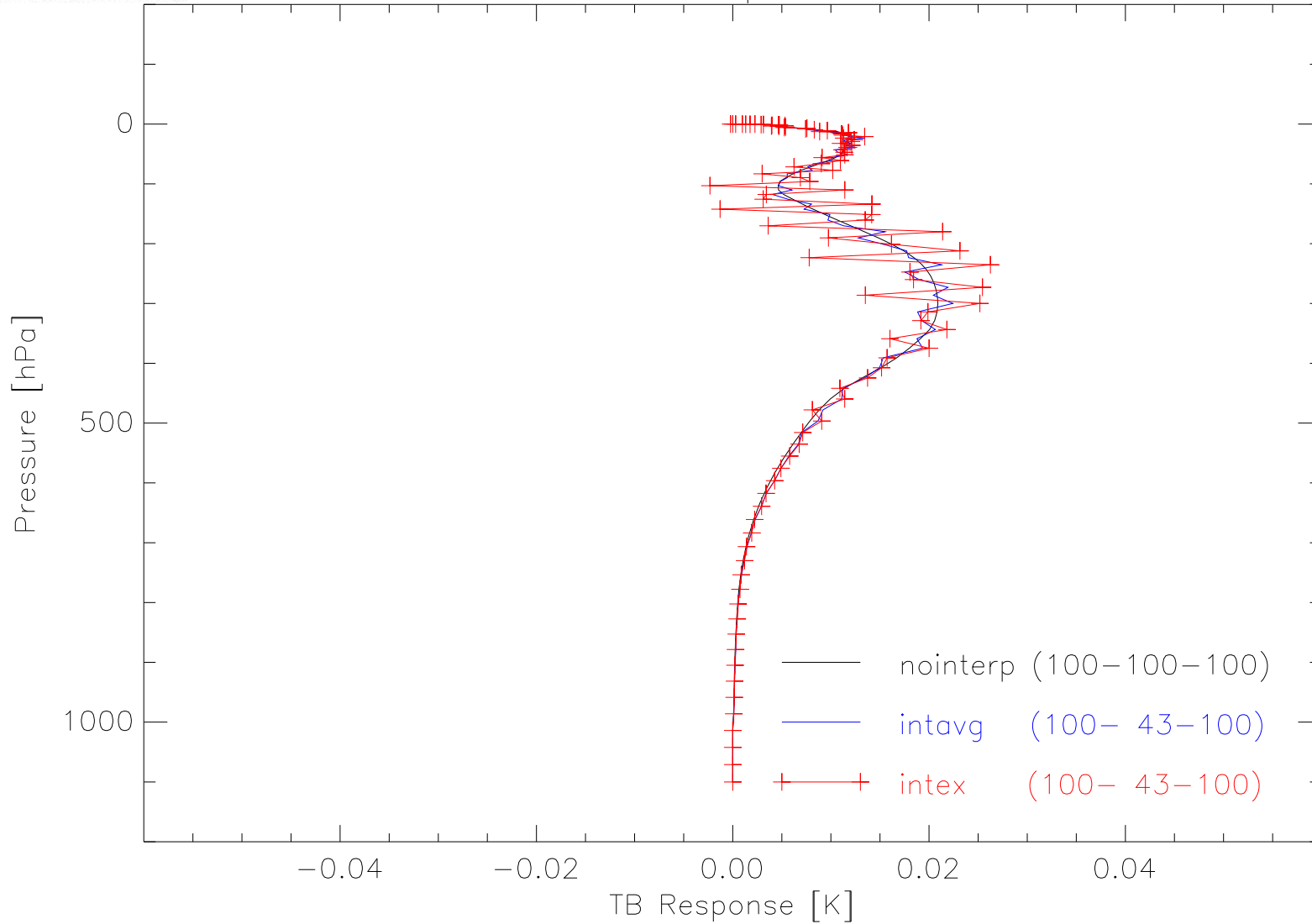
**N.B. + Planck weighted coeff files for a few sensors with broad spectral channels (e.g. SEVIRI)**

# Interpolation of user profile

- The interpolator 'INTAVG' was developed by Yves Rochon et al. (Environment Canada) *ITSC-15 and paper in QJRMS*
- INTAVG avoids the problem of 'blind levels' because all source levels eventually contribute
- Weights applied to user input profile values
- Output profile integrated over weighted input values

# Interpolation 100 (user) 43 (rttov)

HIRS Chan-04: Temperature Jacobians



# Aerosol types available

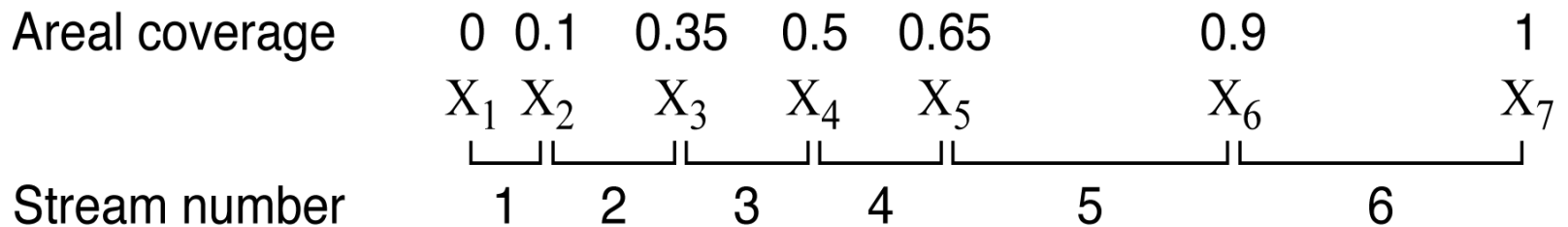
Column 1:	Insoluble	(INSO)
Column 2:	Water soluble	(WASO)
Column 3:	Soot	(SOOT)
Column 4:	Sea salt (acc. mode)	(SSAM)
Column 5:	Sea salt (coa. mode)	(SSCM)
Column 6:	Mineral (nuc. mode)	(MINM)
Column 7:	Mineral (acc. mode)	(MIAM)
Column 8:	Mineral (coa. mode)	(MICM)
Column 9:	Mineral transported	(MITR)
Column 10:	Sulphate droplets	(SUSO)
Column 11:	Volcanic ash	(VOLA)

# Different types of cloud parameterised

Column 1:	Stratus Continental	(STCO)
Column 2:	Stratus Maritime	(STMA)
Column 3:	Cumulus Continental Clean	(CUCC)
Column 4:	Cumulus Continental Polluted	(CUCP)
Column 5:	Cumulus Maritime	(CUMA)
Column 6:	Cirrus	(CIRR)

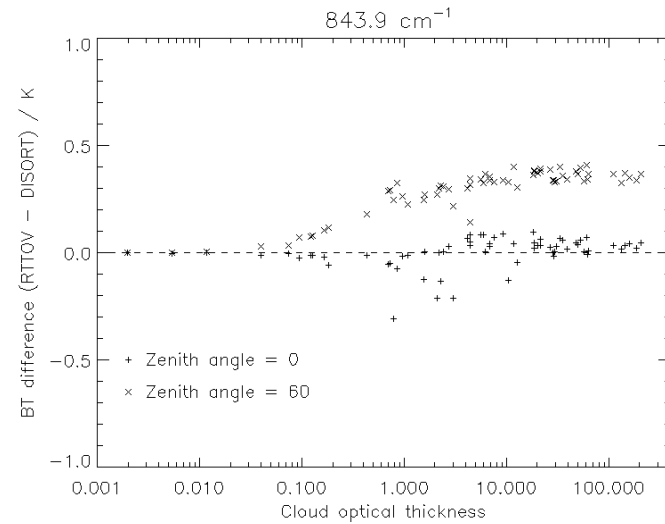
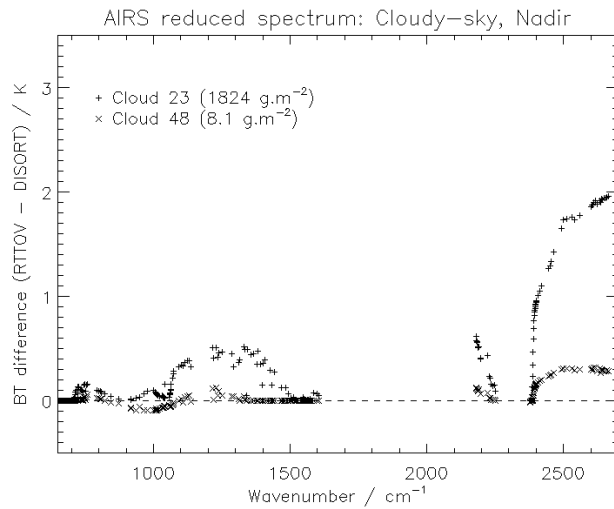
# Representation of cloud

Layer	CFR (%)	Cloud displacement in each stream					
1	0	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
2	50	Blue	Blue	Blue	Yellow	Yellow	Yellow
3	0	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
4	30	Yellow	Yellow	Blue	Blue	Yellow	Yellow
5	80	Yellow	Blue	Blue	Blue	Blue	Yellow
6	0	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
7	0	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow



$$L^{cloudy} = \sum_{s=1}^{n_c} (X_{s+1} - X_s) L_s^{overcast} + L^{clear} (1 - X_{n_c+1})$$

# Validation of cloudy simulations



Radiative impact of stratus maritime cloud type (left) and difference between RTTOV and DISORT calculations (right) for two different cloud profiles.



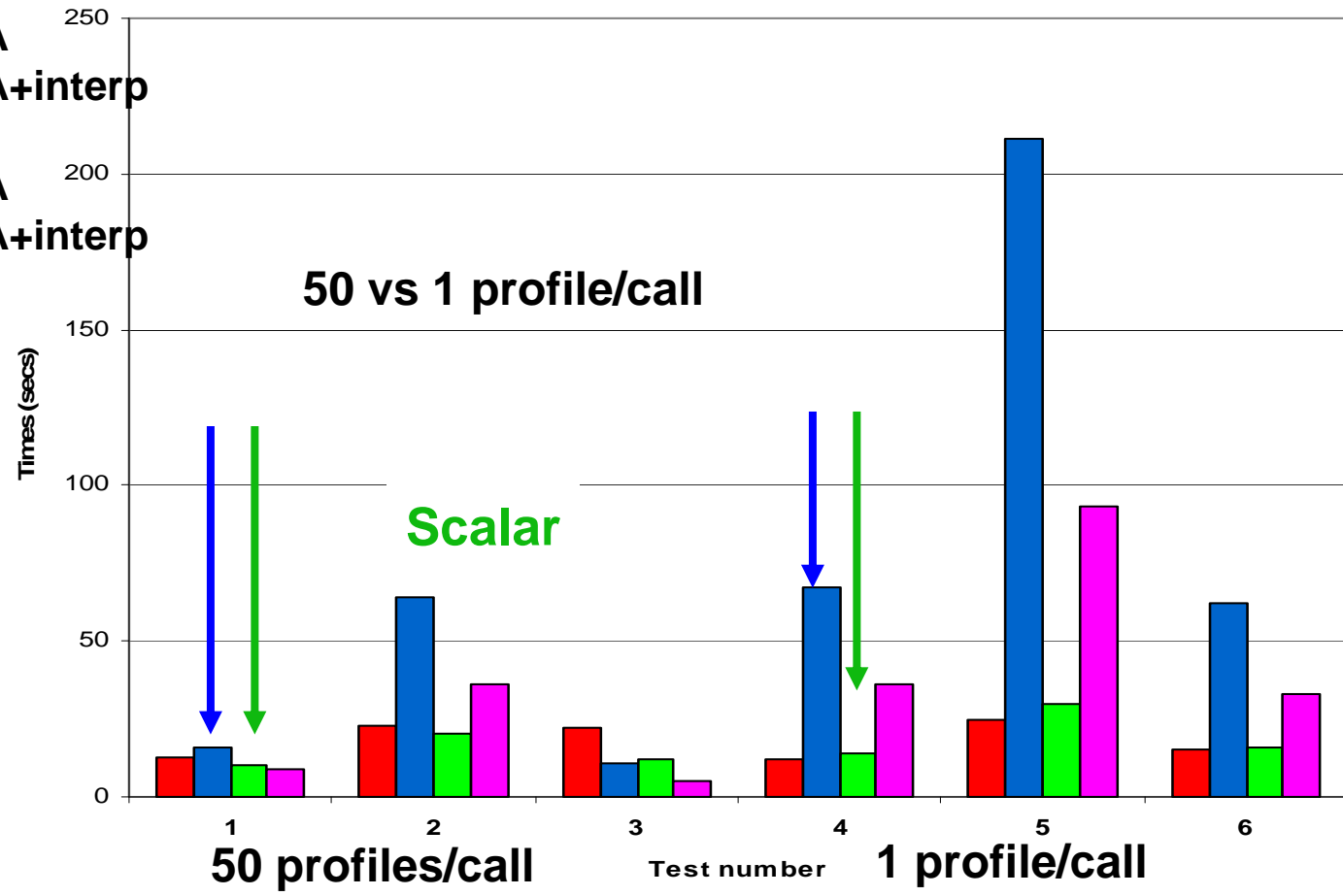


# Forward model times 50,000 profiles for AMSU-A and HIRS

RTTOV-9 Timings

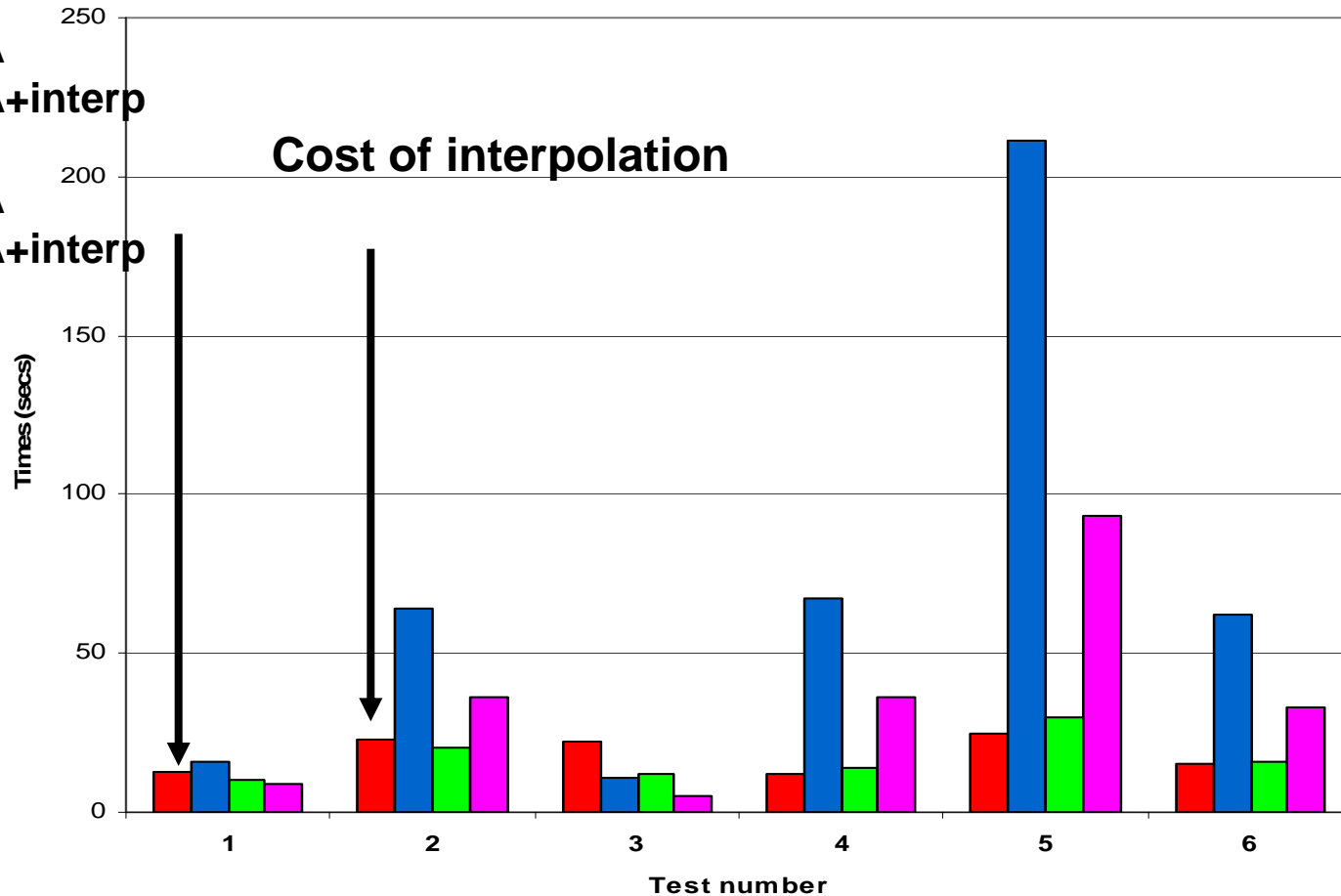


- 1=AMSU-A
- 2=AMSU-A+interp
- 3=HIRS
- 4=AMSU-A
- 5=AMSU-A+interp
- 6=HIRS



# Interpolation costs (official version)

RTTOV-9 Timings



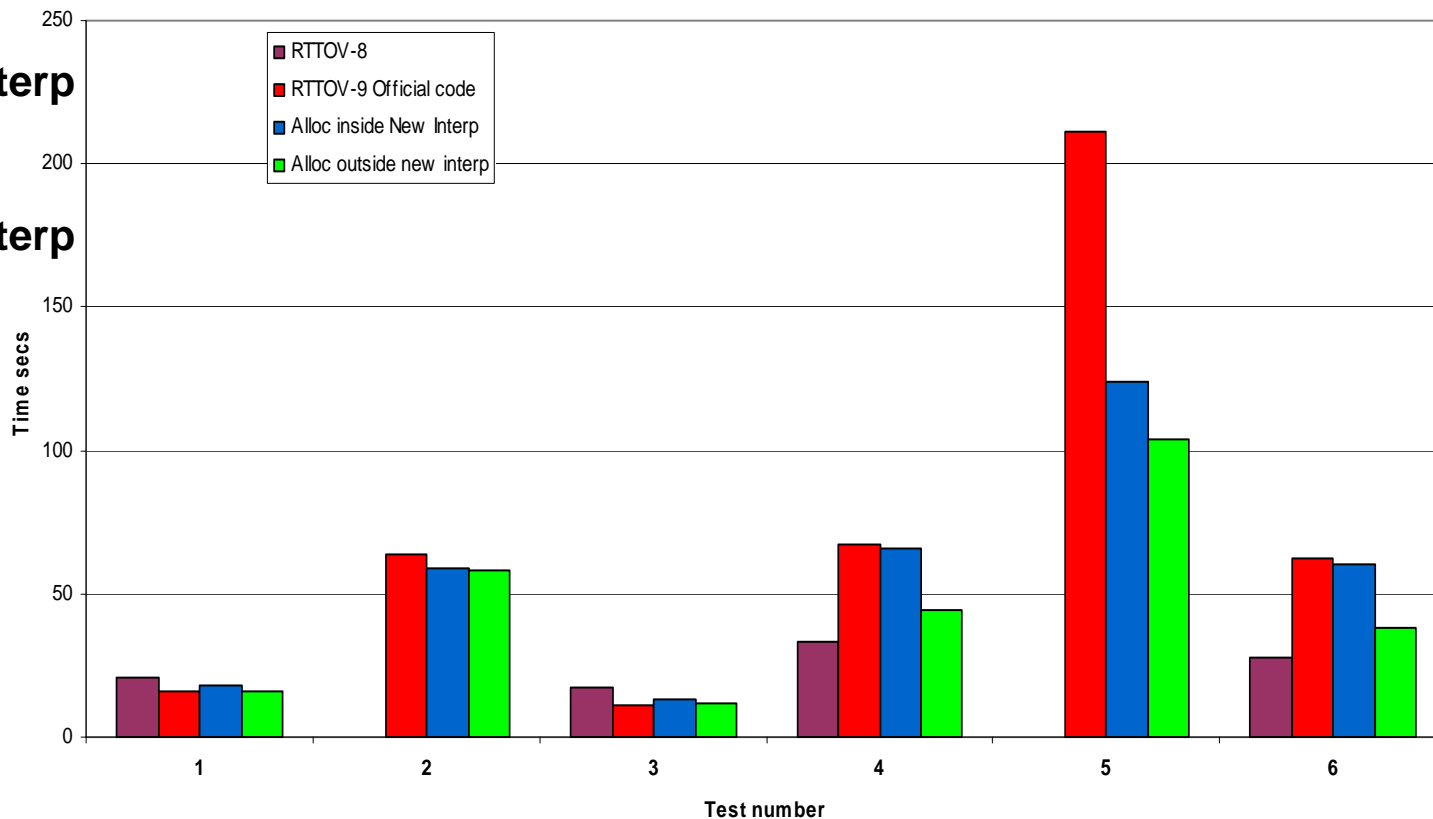
1=AMSU-A  
 2=AMSU-A+interp  
 3=HIRS  
 4=AMSU-A  
 5=AMSU-A+interp  
 6=HIRS



# RTTOV-8 vs RTTOV-9 vs 9+

RTTOV timings on Met Office NEC

- 1=AMSU-A
- 2=AMSU-A+interp
- 3=HIRS
- 4=AMSU-A
- 5=AMSU-A+interp
- 6=HIRS



50 profiles/call

1 profile/call



# RTTOV-9 web site

Version 9\_1 of RTTOV was released in March 2008 and is available to licensed users free of charge. To become a licensed user of RTTOV v9, please send a request using the [RTTOV-9 Request Form](#).

- RTTOV-9 documentation

- [RTTOV-9 Users' guide](#) (pdf)
- RTTOV-9 Science and validation report (pdf) (in preparation)
- [RTTOV-9 Top level design](#) (pdf)
- [Fortran Compilers tested with RTTOV-9 code](#) (pdf)
- [RTTOV-9 performance on different platforms](#) (pdf)

- [RTTOV-9 1 known bugs](#)

Please report any bugs you find in RTTOV-9 using the [NWP SAF Feedback Form](#).

- RTTOV-9 optical depth predictors for AIRS and IASI based on GENLN2 on 100L:

- [AIRS](#) (bzipped file 49Mb)
- [IASI](#) (bzipped file 188Mb)

- RTTOV-9 microwave optical depth predictors for DMSP-14 SSM/T-2:

- [SSM/T-2](#) (bzipped file 32K)

- RTTOV-9 IR aerosol scattering coefficients:

- [AIRS](#) (bzipped file 18Mb)
- [IASI](#) (bzipped file 97Mb)

- RTTOV-9 IR cloud scattering coefficients:

- [AIRS](#) (bzipped file 28Mb)
- [IASI](#) (bzipped file 161Mb)

(note the corresponding RTTOV-7 and RTTOV-8 optical depth coeffs are on the [RTTOV-7](#) and [RTTOV-8](#) pages).

- RTTOVSCATT microwave scattering coefficient files for RTTOV-9:

- Download the following file for AMSU-A: [AMSU-A](#) (bzipped 35 Mb file)
- Download the following file for SSMI: [SSMI](#) (bzipped 9Mb file)
- Download the following file for SSMIS: [SSMIS](#) (bzipped 40Mb file)
- Download the following file for AMSR: [AMSR-E](#) (bzipped 14Mb file)
- Download the following file for TMI: [TMI](#) (bzipped 12Mb file)

Poste de travail

Dossier personnel de rttov

floppy

kmatrix.rtk

layer 60.2- 89.5- CIRR.rtp

profile5.x.rtp

profile52.ps

profile\_52.rtp

radiance.rtr

transmission.rtt

Corbeille

profile\_52.rtp (modified)

File Edit About Panels RTTOV

Log:

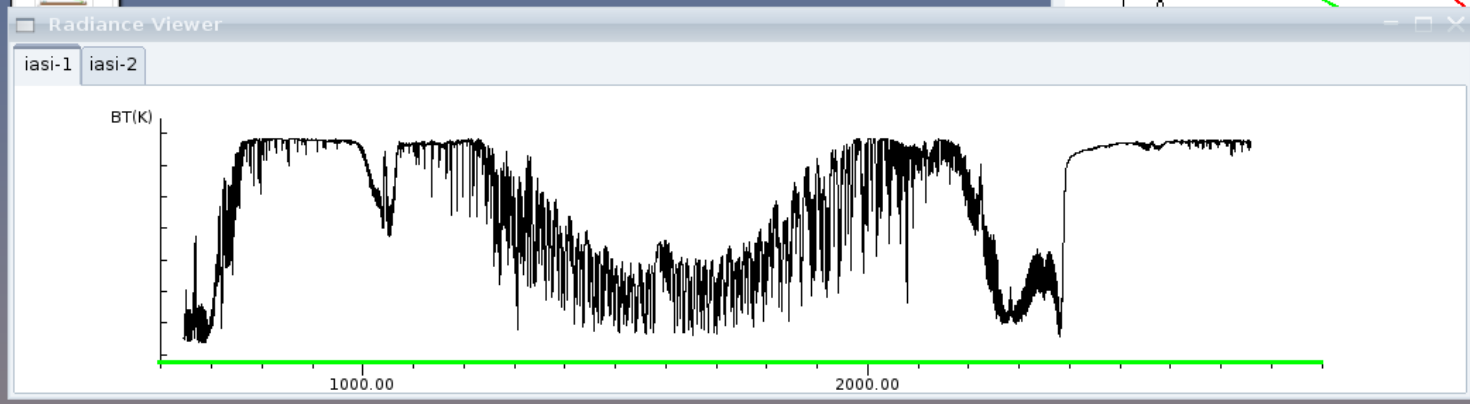
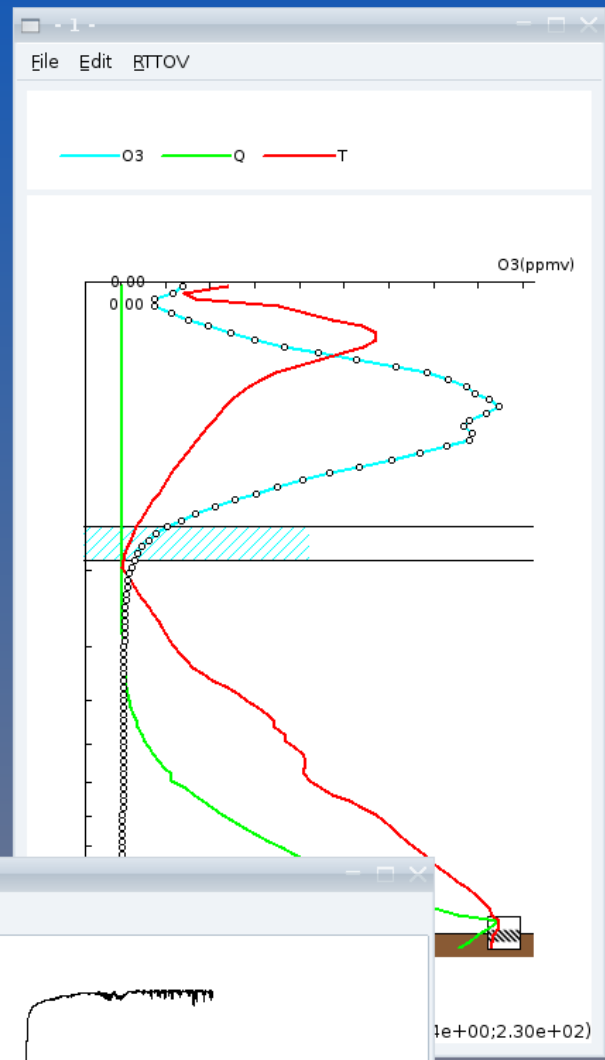
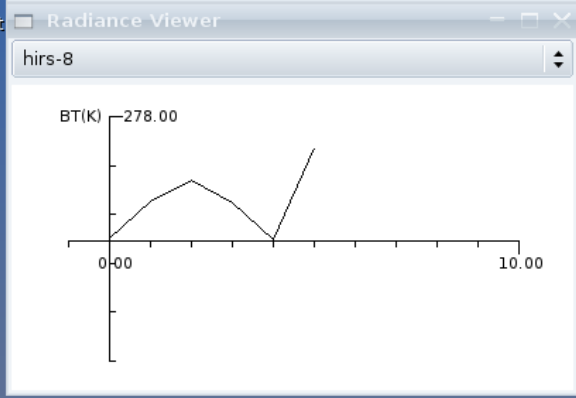
➔

RTTOV

File RTTOV About

Log:

➔



rtt...

Echier

-screen

v-gui.p

# Plans for RTTOV-10

- Include Zeeman splitting for AMSU-A (14) and SSMIS (Yong Han)
- Provide new LBLRTM based coefficients for AIRS/IASI and CrIS
- Add Non-LTE using SARTA or similar approach
- Rewrite coeff generation software and make available to users
- Upgrade FASTEM-3 microwave ocean surface emissivity
- Upgrade FASTEM-3 over land for lower frequencies (SMOS)
- Make 'hidden' top layer to be defined by user
- Add new SSU predictors for reanalyses
- Design for including PCRTM capability
- *Simple VIS/NIR optical depth and scattering calculations*



# RTTOV-9 LITE CD

Free CD with sample of RTTOV-91 code

- Only forward model (not TL/AD/K)
- HIRS and AMSU coeff files provided
- Computes top of atmosphere radiances
- Surface emissivity must be supplied
- No cloud or aerosol capability

**Available from me while stocks last.**

To get official code go to:

[http://www.metoffice.com/research/interproj/nwpsaf/request\\_forms/request\\_rttov\\_9.html](http://www.metoffice.com/research/interproj/nwpsaf/request_forms/request_rttov_9.html)

**and complete licence form to get free copy of RTTOV-91**



Met Office



# Questions and answers



International TOVS Study Conference, 16<sup>th</sup>, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008.  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2008.